# NASA SBIR 2005 Phase I Solicitation

## X11.02 Human Health Countermeasures

**Lead Center: JSC**

**Participating Center(s): ARC, GRC, MSFC**

In order for humans to live and function safely and efficiently in space or in the hypogravity of the Moon (1/6g) or Mars (3/8g), a good understanding of the effects of micro- and hypogravity and other factors associated with the space environment on human physiology and human responses to the space and extra planetary environments is required. A variety of countermeasures must be developed to oppose the deleterious changes that occur in space and upon subsequent exposure to other gravitational fields. The ability to monitor the effectiveness of countermeasures and alterations in human physiology during space exploration missions, particularly when several countermeasures are used concurrently, is equally important. This subtopic seeks innovative technologies in several very specific key areas. Since launch costs relate directly to mass and volume, instruments and sensors must be small and lightweight with an emphasis on multi-functional capabilities. Low power consumption is a major factor, as are design enhancements to improve the operation, design reliability, and maintainability of these instruments in the environment of space and on planetary surfaces. As the efficient use of time is extremely important, innovative instrumentation setup, ease of usage, improved astronaut (patient) comfort, noninvasive sensors, and easy-to-read information displays are also very important considerations. Extended shelf life and ambient storage conditions of consumables are also key necessities. Ability to operate in 0g, 1/6g, and 3/8g becomes more important as we march towards human Moon and Mars missions.

**Exercise and Related Hardware**

Development of an immersive visual display system is required to be interfaced with treadmill exercise devices. This system may not be head-mounted but could be free standing and provide at least a 180Â° field of view. This visual display would allow visual flow patterns to be displayed to a non-encumbered subject during in-flight or on-surface treadmill exercise. In addition, miniaturized exercise hardware (treadmill or resistance exercise); physiological monitoring devices; and metabolic gas (carbon dioxide and oxygen) analysis systems for use with exercise and miniaturized interactive feedback and entertainment systems.

A tool or toolkit should simulate and visualize the exercise device design and performance. A comprehensive, scaled 3D/virtual human model interface would be valuable to show biomechanical and kinetic effects of the exercise device. Relative physiological data from anthropometry to stress/fatigue to trauma/insult onset should be targeted. If in-flight/on-orbit micro gravitational and planetary surface gravitational forces can be simulated, this could help produce germane simulations with which to implement new designs and products. A time-delay algorithm would be advantageous in helping provide for latency-moderated haptics (force-feedback) and long-distance teleoperative control. This will allow remote teleoperation with force-feedback despite the high latencies involved.

**Noninvasive Pharmacotherapy and Monitoring**

Development of innovative technologies resulting in noninvasive methods for diagnosis, treatment, and therapeutic drug monitoring is needed to facilitate effective pharmacotherapy of humans in space. Many questions remain about the effectiveness of pharmaceuticals in micro- and hypo-gravity environments, which may interfere with their activity by sensitizing or desensitizing the crewmember or interfering in other ways with the desired physiological

effect. Micro-encapsulation of drugs, radio contrast agents, crystals, and development of novel drug delivery systems wherein immiscible liquid interactions, electrostatic coating methods, and drug release kinetics from microcapsules or liposomes can be altered under microgravity. Devices for continual monitoring of physiology during pharmacotherapy would also be advantageous to ensure that on-orbit expression of therapies relates to on-Earth histories.

**Device for Providing Increased Neuromuscular Activation during Spaceflight**

Astronauts returning from spaceflight exhibit post-flight postural and gait instabilities that are a result of neural adaptation to microgravity. A small, lightweight countermeasure device is required to stimulate somatosensory receptors on the plantar surface of the feet during in-flight exercise with the goal of increasing neuromuscular activation and enhancing sensorimotor integration. This system would integrate with in-flight exercise hardware and coupled with visual stimulation systems would allow a more complete sense of immersion to enhance in-flight postural and locomotor training.

**Device for Measuring Body Fluid Shift**

A body impedance device to measure fluid shifts in four segments of the body associated with a short-radius centrifuge. The device should measure the following parameters, namely, resistance, change in resistance and rate of change of resistance and reactance. The device should withstand g forces (5g) produced by centrifugation and meet safety standards such as subject isolation.

**MEMS-Based Human Blood Cell Analyzer**

Development of a small, automated and micro- and hypo-gravity capable instrument that will analyze micro liter quantity of human whole blood and provide a complete blood cell count (RBC, WBC, platelet, hemoglobin concentration, hematocrit, WBC differential, and calculated RBC indices) that correlates with traditional ground-based impedance or light-scattering technologies is needed. Likely devices based on MEMS will employ a biocompatible combination of micro fluidics, micromechanics, micro-optics, microelectronics, and data telemetry capabilities in an integrated handheld package with a user-friendly operator interface.

**Cell/Tissue Analog Studies**

Cell/Tissue analog studies in ground-based, microgravity-analog bioreactors allow us to understand the ill-effects of microgravity and radiation on human tissues-especially, bone, muscle, and cardiac and immune response. Technologies that allow automated biosampling, lyophilization of mammalian cells, miniaturized protein microarray analyzer, tools derived from Bionanotechnology relevant to the understanding are of interest.